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THE SUNFLOWER DWARF MUTANT *dw*1: EFFECTS OF GIBBERELLIC ACID TREATMENT

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SUMMARY

A severe dwarf mutant affecting vegetative and reproductive growth arose spontaneously in our sunflower-breeding nursery in 1999. The segregation data did not deviate significantly from the expected ratio for a recessive monogenic character. Periodic treatment with gibberellic acid (GA3) was effective to revert to the wild type phenotype and internode elongation was directly related to the GA3 concentration. The results suggest that the mutant gene is involved in the enzymatic pathway of GA synthesis.

Key words: dwarf, gibberellic acid, mutant, sunflower

INTRODUCTION

The use of dwarfing genes in several programs of genetic improvement has given important contribution to agriculture *via* the development of new short-stature varieties resistant to lodging. Many cereal grains actually cultivated over the world incorporate in their genetic background different dwarfing genes (Borlaug, 1983).

The recovery and the extensive use of these genes in plant breeding programs have been important for a better understanding of the genetical and physiological mechanisms implicated in plant growth and development (Chandler *et al.*, 1999; Zanewich *et al.*, 1991).

The pathway of gibberellic acid biosynthesis has been studied in many dwarf mutants (Heliwell *et al.*, 1998; Hedden, 1996; Ogawa *et al.*, 1999). In this paper we report preliminary results to characterize the genetic and physiology of a severe dwarf mutant in sunflower.

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MATERIALS AND METHODS

Ten sunflower dwarf mutant *dw*1 arose spontaneously in a F_3 progeny of 200 plants originally derived from a cross between two restorer lines (R82 xR 2797) selected at the Plant Biology Department of Pisa University.

All the plants of the progeny were self-pollinated to obtain the subsequent generation.

Dwarf pants did not produce any seed. Hundred seeds from each fertile F_3 plant were sowed in seedling trays in the greenhouse in April 2000. After two weeks, when seedlings were at the stage of two true leaves, it was again possible to recover dwarf mutants based on the absence of internode elongation and the colour and shape of leaves. The percentage of dwarf mutants was calculated and dwarf plants were then transplanted in pots for gibberellic acid treatment.

Greenhouse experiments were carried out to determine whether the mutant was sensitive to exogenous application of gibberellic acid.

Experiment 1:

Dwarf plants were subdivided in 6 groups of 5 plants each and sprayed weekly till flowering with 20 cc of a GA3 solution at different concentrations (ppm) 0, 0.01, 0.1, 1, 10, 100.

Data on stem length and internode elongation were collected till flowering at seven-day intervals.

Experiment 2:

In the plants treated as in exp.1 gibberellic acid treatment was suspended after 2, 4, 6, 8 weeks.

RESULTS AND DISCUSSION

Among the 200 plants of the original F_3 progeny we recovered 10 dwarf plants without any internode elongation. Although the dwarf plants did not produce any seed, it was still possible to recover the mutation in 25 progenies of the normal plants self-pollinated by paper bags. In this case the segregation ratio was 3:1 ($0.1<p>0.5$) (data not shown), indicating that the mutation is recessive and controlled by a single gene named *dw*1.

Considering the different segregation rates between the original F_3 (19:1) and the heterozygous F_4 plants (3:1), we suppose the chimaeric nature of the F_2 plant from which the mutation originated (Cecconi *et al.*, 1992), These data apply to a mutated sector of ¼ of the capitulum surface (data not shown). This conclusion was supported also by the percentage of segregating progenies that is only 25 out of 200.

Figure 1: Dwarf mutant at flowering

Figure 2: Dwarf plant with respect to the wild type

The main morphological characteristics of *dw1* mutant are (Figures 1 and 2):

- absence of internode elongation resulting in a final height between 10 and 30 cm (normal height 120-150);
- delayed flowering for about 40 days;
- crenate leaves with a deep green color;
- abortive ovary development;
- low percentage of viable pollen that remains in the flower tube due to the absence of anther elongation.

The greenhouse experiments clearly indicate that (Figures 3 and 4):

- periodic treatment with gibberellic acid (GA3) was effective to revert to the wild type phenotype;
- the best result was achieved by spraying the leaves with a 10 ppm solution of GA3 each week;
- internode elongation was directly related to the GA3 concentration;
- the periodic treatment with 100 ppm turned out to be toxic - after 3–4 applications the apex became brown and then died;
- the GA3 treatment permits a normal expansion of the leaf lamina that reverts from deep green to light green color;
- the duration of GA3 effects was lost after about 7 days permitting to have on the same plant the alternation of normal and mutated characteristics;
- particularly interesting seem to be the effects of gibberellic acid on the floral

organ development: fertility was restored by gibberellic acid treatment only for the female apparatus, while pollen grain development was aborted in an early phase of microsporogenesis.

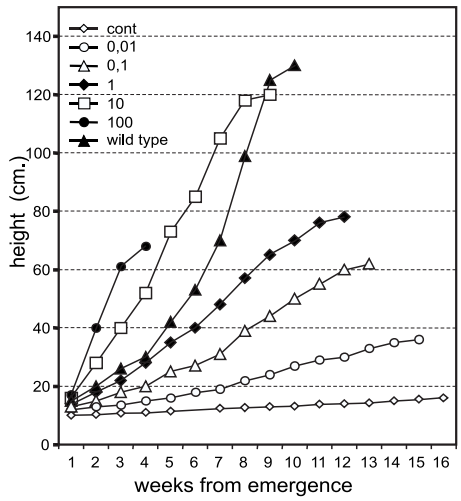

Figure 3: Effect of the periodic treatment with different GA3 concentrations on stem length of the dw1 sunflower dwarf

Many dwarf mutants described in other plant species are deficient in gibberellin synthesis (Goldman *et al.*, 1997; Ueguchi *et al.*, 2000). Deficiencies of this hormone often result in a collapsed phenotype characterized by a rosette appearance with dramatically shortened internodes (Waicott *et al.*, 1991; Rood *et al.*, 1989). This is the first report on the recovery and description of such a type of mutant in sunflower. Studies are in progress to find the metabolic step at which gibberellin precursors accumulate in the tissues.

Figure 4: GA3 effects induced by different timing of gibberellic acid treatments

1 Control dwarf plant
2 Plant sprayed with GA3 10 ppm for the first two weeks only
3 Plant weekly sprayed with GA3 10 ppm
4 Control wild type plant

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MUTANTE ENANO DEL GIRASOL *dw*1: EFECTO DEL TRATAMIENTO POR EL ACIDO GIBERELICO

RESUMEN

El mutante excepcionalmente enano, que influye sobre el crecimiento vegetativo y generativo, fue obtenido espontaneamente en nuestro plantio de cultivo para la seleccion del girasol en 1999. Los datos sobre la segregacion no se diferenciaban considerablemente de la relacion esperada para el caracter monogeno recesivo. El tratamiento de tiempo al tiempo por el acido giberelico (GA3) asegura eficazmente la vuelta al fenotipo del tipo silvestre, y el aumento de largo del internodio era ligado directamente con la concentracion de GA3. Los resultados obtenidos indican que el gen responsable para la mutacion es incluido en la via biosintetica enzimatica de la sintesis del acido giberelico.

LE MUTANT NAIN DU TOURNESOL *dw*1: EFFETS DU TRAITEMENT À L'ACIDE GIBÉRELLIQUE

RÉSUMÉ

Un mutant exceptionnellement nain, qui affecte la croissance végétative et reproductrice est apparu spontanément dans notre nursery de tournesol en 1999. Les données sur la ségrégation ne se différenciaient pas significative-

ment du rapport attendu pour le caractère récessif monogénique. Un traitement périodique à l'acide gibbérellique (GA3) s'est montré effectif pour le retour au phénotype de type sauvage et l'élongation internodale était directement reliée à la concentration en GA3. Les résultats obtenus suggèrent que le gène responsable de la mutation est impliqué dans le chemin enzymatique de la synthèse de GA.